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ABSTRACT

This study compared orthoptic vision development and balance performance of nonhandicapped and learning disabled children between the ages of 10 and 13 years of age. Each subject was individually administered two orthoptic vision screening tests (Cover Test and Biopter), a dynamic balance test using a changing consistency board, and two static balance tests (eyes open and eyes closed) on the soft area of a changing consistency board. Test results performed on the static balance data indicated a significant difference in the sums of the score ranks of the two groups with Stork Stand Eyes Open test. The nonhandicapped group balanced longer than the learning disabled group with both static balance tests. Results of the study suggest that the Cover Test should be utilized to examine orthoptic vision when testing static balance performance of learning disabled children. (JD)

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An Examination of Orthoptic Vision and Balance Performance of Nonhandicapped and Learning Disabled Children

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Abstract

The purpose of this study was to compare orthoptic vision development and balance performance of nonhandicapped and learning disabled children. Subjects were nonhandicapped (n = 10) and learning disabled (n = 10) children between the ages of 10 and 13 years who attended an urban elementary school located in a southwestern Michigan city. The two groups were equivalent with respect to age and gender, with the proportion of male-to-female subjects 9:1 in each group. Each subject was individually administered two orthoptic vision screening tests (Cover Test and Biopter), a dynamic balance test using a changing consistency board, and two static balance tests (eyes open and eyes closed) on the soft area of a changing consistency board. Independent samples chi-square analyses of the orthoptic vision tests indicated that one subtest score of the Cover Test (watch right eye for lateral phoria) was significant [χ^2 (18, n = 20) = 13.33, $p < .01$]. A post hoc analysis for chi-square (Schleiffers, 1983) revealed that differences between proportions of groups existed with both rows (no problems and exo-esophoria--greater proportion of nonhandicapped subjects with no problems and learning disabled subjects with lateral phorias). Mann-Whitney U test results performed on the static balance

data indicated a significant difference in the sums of the score ranks of the two groups with Stork Stand Eyes Open test. The nonhandicapped group balanced longer than the learning disabled group with both static balance tests. Results of this study suggest that the Cover Test should be utilized to examine orthoptic vision when testing static balance performance of learning disabled children.

An Examination of Orthoptic Vision and Balance Performance of Nonhandicapped and Learning Disabled Children

Difficulty in maintaining sustained equilibrium and poor postural responses are characteristic of many learning disabled children (Pyfer, 1983; Pyfer & Alley, 1978; Quiros, 1976; Quiros & Schrager, 1979). Results of studies utilizing learning disabled subjects and nonhandicapped comparison groups are conflicting in regard to describing balance performance of learning disabled children. Some investigators reported that nonhandicapped subjects performed better than learning disabled subjects with balance tasks (Bruininks & Bruininks, 1978; Cinelli & DePaepe, 1984; Orfitelli, 1977) whereas other investigators reported no significant difference between groups in balance performance (Folsom-Meek, 1986; Kendrick & Hanten, 1980; Morerod, 1982; Schneider, 1981). Gorman (1983) noted significant differences between groups favoring the nonhandicapped group in dynamic balance performance but no difference between groups in static balance performance.

The underlying components of balance performance are complex and difficult to isolate. In addition to strength requirements to perform balance tasks, sensory input to maintain equilibrium is provided by the visual,

proprioceptive, vestibular, and tactile systems. Integration of these contributing sensory input systems and reflexes is a prerequisite to maintaining equilibrium, and the cerebellum and reticular formation are involved in a regulatory capacity. Because the external eye muscles depend on input from the vestibular and proprioceptive systems, orthoptic vision measurements are confounded by these variables. The orthoptic visual system, however, is one sensory component contributing to balance performance that can be easily observed and measured by educators.

Evidence from recent research indicates that when the depth perception variable is controlled, learning disabled male children's performance is not different from that of nonhandicapped male children (Folsom-Meek, 1986). In this study, 10% of potential learning disabled subjects were not included because they displayed poor depth perception (orthoptic vision problems). When poor depth perception was controlled, however, balance performance of learning disabled subjects on five static balance tests performed on a forceplate did not differ significantly from that of nonhandicapped subjects. Because depth perception screening measures were used to eliminate potential subjects displaying problems, it is not known whether these children would have also displayed balance problems.

However, reports in the literature indicate a high incidence of orthoptic vision problems among children who have reading disabilities and other learning problems (Haddad, Isaacs, Onghena, & Mazor, 1984; Money, 1966; Pyfer, 1983; Pyfer & Alley, 1978; van Eyck, 1980).

The vestibular and proprioceptive systems work very closely with the visual system to contribute to balance performance. Two pediatric neurologists, Quiros and Schrager (1979), recommended the use of a changing consistency board to measure vestibular, proprioceptive, and ocular functioning, and balance performance. The changing consistency board is a naughahyde-covered wooden board whose consistency is abruptly changed from hard to soft. To measure dynamic balance performance, the child walks from one end of the board to the other, and the motor behavior of the child when he or she reaches the soft spot on the board is recorded with a video camera. When the child reaches the soft spot, he or she must employ primarily vestibular reflexes in order to maintain equilbrium. According to Quiros and Schrager (1979), when vestibular responses are adequate, the child should demonstrate responses of the asymmetric tonic neck reflex (ATNR) by extension and abduction of the ipsilateral arm whereas vestibular dysfunction is indicated when the

contralateral arm extends and abducts.

Measuring static balance performance on the changing consistency board has also been recommended by Quiros and Schrager (1979). The child stands on the soft spot of the board in the one-leg position with eyes open and eyes closed. As with the dynamic balance test on the changing consistency board, appearance of the asymmetric tonic neck reflex is considered normal. Response of the ipsilateral and contralateral arms and direction of trunk sway in relation to the weight-bearing leg is recorded on film. In addition, the examiner times the duration that the subject was able to balance with eyes open and eyes closed according to test protocol.

Assessment of postural reflexes, especially those mediated at the brainstem level, has been the subject of recent investigations. The ATNR has been the most commonly-measured postural reflex. In Finocchiaro's (1974) study, the ATNR was one of three reflexes measured. In addition to five clinical observations, the ATNR was the only reflex measured by Goldstein, Katz, and O'Brien (1981). Although this reflex is thought to be integrated by six months of age, the investigators postulated that the presence of some primative reflexes in children age six and younger may be normal rather than a sign of learning

disabilities. This premise was because very few test scores and clinical observations (including ATNR) clustered together for subjects in a high risk for learning disabilities group.

Pearson (1987) measured postural reflexes and motor performance of 24 learning disabled male children between 9 and 12 years of age with Fiorentino's (1977) test, and the ATNR was present in 16 of 24 subjects. Pearson's study consisted of two groups--normal reflex group (0 - 4 abnormal reflexes) and abnormal reflex group (5 or more abnormal reflexes). Although not statistically significant, the balance subtest of the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks, 1978) was the only subtest in which the scores of the abnormal reflex group were markedly lower than those of the normal reflex group.

The purpose of the present study was to compare orthoptic vision development and balance performance of nonhandicapped and learning disabled children. Specifically, orthoptic vision was measured by two screening instruments. Balance was assessed on a modified changing consistency board as recommended by Quiros and Schrager (1979) by means of a dynamic balance test and two static balance tests (Sloan, 1956). Hypotheses of independence (no difference between groups in the

proportion of test scores) were tested with the orthoptic vision and dynamic balance test scores. For the static balance tests, the null hypotheses were that the sums or score ranks of the two groups were equal. All hypotheses were tested at the .05 significance level.

Method

Subjects

Subjects were nonhandicapped (n = 10) and learning disabled (n = 10) children between the ages of 10 and 13 years (M = 11.64 years) from a medium-sized city in Michigan. In each group, the proportion of male-to-female subjects was 9:1, which is in agreement with the gender proportion cited in recent literature (French & Jansma, 1982; Meyen, 1978). The nonhandicapped subjects were receiving no special education services, whereas the learning disabled subjects were receiving special education services. The learning disabled group was selected first; all children who returned the signed consent forms were included as subjects in the study. Potential nonhandicapped subjects were procured from school records and matched to learning disabled subjects according to gender and age. All possible nonhandicapped subjects were given the opportunity to participate in the study; subjects

in this group were randomly selected from returned permission forms.

Instrumentation

The Cover Test (Pyfer & Johnson, 1981), a biopter (Stereo Optical, Inc.), and a modified M-125 Biopter Vision Test (Vodnoy, 1970) were employed for orthoptic vision testing. The Cover Test detects phoric and tropic conditions at near point. With the biopter tests, five far point and two near point tests were used to examine vertical and lateral phorias, central fusion, and stereopsis.

The changing consistency board was modified from that described by Quiros and Schrager (1979) in that it was 6 in. shorter. The dimensions of the board were 6 ft x 1 ft x 3 in. The surface at each end was hard; the surface in the center was soft. The entire board was covered with naughahyde to prevent the soft surface from being visible to the subjects. Refer to Figure 2 for a diagram of the modified changing consistency board.

A posture grid used in conjunction with an overhead projector and a video camera were utilized for recording balance performance. The grid was projected behind the board and consisted of 4 x 4.25 in. rectangles on the wall. Distances in the filming procedures included: (a)

wall to closer end of changing consistency board--15 in., (b) wall to camera--25 ft, and (c) beginning of overhead projector to closer end of changing consistency board--54 in.

Procedure

Data collection took place at an elementary school in Kalamazoo, Michigan. Each subject was individually administered the orthoptic vision tests, and the dynamic and two static balance (stork stand) tests on the soft surface of the changing consistency board.

For orthoptic vision testing, subjects were administered the Cover Test (Pyfer & Johnson, 1981) followed by the biopter tests. Subject responses were recorded on forms for later analyses. See Figure 1 for the Cover Test protocol.

In the dynamic balance test, subjects walked with eyes closed from one end of the board to the other while performance was recorded with a video camera. With the two stork stand tests, subjects performed on the preferred foot with determination of the preferred foot following the procedure recommended by Bruininks (1978) with eyes open (SSEO) and eyes closed (SSEC) on the soft area of the changing consistency board. The criterion position was the sole of the nonbalance foot placed against the inside of

the knee of the standing leg with palms of hands resting on the outside of the thighs (Sloan, 1956).

Each subject was given a practice trial prior to the stork stand tests. For the trial that was recorded, subjects achieved the criterion position before timing with a stopwatch was begun.

Analyses of Data

Applesoft BASIC software, NONPARAMETRIC STATISTICS (Schleiffers, 1983) was used to test the orthoptic vision and dynamic balance hypotheses by computing the chi square statistic for two groups (2 x 2) for each of the test scores. Cutoff points for categories utilized (passing and referral) were determined according to criteria recommended by Vodnoy (1970). The categories for dynamic balance were extension/abduction of arm on either ipsilateral or contralateral side relative to the weight-bearing leg. For the stork stand tests, Apple BASIC software (Elzey, 1984) was used to test the hypotheses with Mann-Whitney U tests.

For the age data and stork stand tests, data files were created on the DECsystem 10 mainframe computer. A computer program was written to calculate descriptive statistics using BMDP7D (Dixon, 1983).

Results

Cover Test scores analyzed by chi-square statistical techniques included: (a) cover left eye and watch right eye, (b) uncover left eye and watch left eye, (c) cover right eye and watch left eye, and (d) uncover right eye and watch right eye. Chi-square analyses of far-point orthoptic vision test scores were performed with the following variables: (a) vertical phoria, (b) lateral phoria, (c) central fusion, (d) stereo runners, and (e) stereo numbers. Near-point orthoptic vision test scores analyzed were lateral phoria and central fusion.

Three cover test chi-square values and all far- and near-point Biopter test and square values were nonsignificant. Only the cover test score, uncover right eye and watch right eye, was significant [χ^2 (18) = 13.33, $p < .01$]. A post-hoc analysis revealed that differences in proportions of groups existed with both rows (no problems and exo/esophoria--greater proportion of nonhandicapped subjects with no problems and learning disabled subjects with lateral phorias.

A chi-square analysis performed on the dynamic balance test scores revealed a nonsignificant chi square value. There were no differences in proportion of the groups in

exhibiting extension and abduction of the arm on either the ipsilateral or contralateral side in relation to the weight bearing leg.

Descriptive statistics computed on the subject groups for stork stand eyes open test (SSEO) and stork stand eyes closed test (SSEC) included ranges, means, and medians. See Table 1 for these descriptive statistics. Results of a t-test indicated no significant difference between the means of the two groups with respect to age.

Time-in-balance was the dependent variable for the two static balance tests. The data were first analyzed using a BMDP3V multivariate t-test program (Dixon, 1983). Results of this analysis indicated that the assumption of homogeneity of variance was not satisfied because the Levene's test values were too low. Therefore, the nonparametric counterpart of the t-test, the Mann-Whitney U test was employed to test the two null hypotheses that the sums of score ranks are equal. For the Stork Stand Eyes Open test, the smaller observed U value was 15. Because this value was smaller than the tabled U value of 23 (Siegel, 1956), the null hypothesis for this variable was rejected. The smaller observed U value of 26.5 was greater than the tabled U value of 23 (Siegel, 1956) with the Stork Stand Eyes Closed test; therefore the null hypothesis for

this variable was accepted. With both static balance tests, the nonhandicapped group balanced longer than the learning disabled group.

Discussion

Because nonparametric statistical tests were utilized to analyze data and the absence of randomization of subject group membership and selection of the learning disabled subject group, results of this study cannot be generalized and should be regarded as preliminary.

Reports in the literature suggest that learning disabled children have orthoptic vision problems but there has been a dearth of research to substantiate these suggestions. In this study, one Cover Test item discriminated between the two groups of children. A larger proportion of learning disabled children demonstrated exo/esophoria with the right eye than nonhandicapped children. Because phoric conditions are temporary (i.e., the eye does not sit in misalignment but fluctuates between aligned and misaligned positions), it would be difficult to observe these tendencies without the use of screening measures such as the Cover Test.

The dynamic balance test did not differentiate between the two subject groups. Although test protocol and

statistical treatment of data varied among investigations of dynamic balance performance of learning disabled children, this finding does not agree with results of several studies (Bruininks & Bruininks, 1977; Cinelli & DePaepe, 1984; Gorman, 1983; Orfitelli, 1977). Based on results of previous research, one would expect to find more learning disabled children with problems but this was not the case with the present study. To investigate Quiros & Schrager's theory more thoroughly, future research needs to be conducted with dynamic balance performance on the changing consistency board.

Both static balance tests were performed on the soft portion of the changing consistency board, which is believed to be a harder task than standing on the floor. The nonhandicapped group performed the Stork Stand Eyes Open test significantly better than the learning disabled group. With the nonhandicapped group, there was no variability with this test. The lack of variability was surprising because some variability would be expected to occur within this group, especially because they were randomly selected. It is probable that the learning disabled group would perform more poorly than the nonhandicapped group on this test because of the significance of the Cover Test item. Causality of Stork

Stand Eyes Open test performance, however, can only be suspected and cannot be inferred. At least 100 subjects are necessary to determine an accurate relationship with a biserial correlation (Glass & Hopkins, 1984), and regression analysis would be necessary to determine prediction of static balance performance based on the significant Cover Test score. The number of subjects in this study was too small to perform this analysis.

Although the mean and median of the nonhandicapped group were larger than the learning disabled group, there was no significant difference between the sums of the score ranks with the Stork Stand Eyes Closed test. Balancing with the eyes closed is a more difficult task than with the eyes open because vision contributes so greatly to balance performance. Both subject groups had lower time-in-balance scores on this test than with the eyes open test.

Based on the results of this study, it can be concluded that a greater proportion of learning disabled children exhibit orthoptic vision problems than nonhandicapped children of the same age and gender and that nonhandicapped children perform better than learning disabled children on an eyes open static balance test. These results suggest that the Cover Test should be utilized to examine orthoptic vision concurrent with

testing static balance performance of learning disabled children.

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Table 1

Description of Subject Groups on Static Balance Test Scores

Variable	Range (low - high)	M	Mdn
SSEO [a]			
NH [c]	0.00 (10.00-10.00)	10.00	10.00
LD [d]	8.70 (1.30-10.00)	6.03	5.85
SSEC [b]			
NH [c]	3.60 (1.00-4.60)	3.28	3.35
LD [d]	7.10 (0.80-7.90)	2.45	1.70

Note. Measurement units are expressed in seconds.

[a] SSEO = Stork Stand Eyes Open test.

[b] SSEC = Stork Stand Eyes Closed test.

[c] NH = nonhandicapped subject group.

[d] LD = learning disabled subject group.

Figure 1. Cover Test protocol (Pyfer & Johnson, 1981)

Child is seated in a chair facing a seated examiner and is able to fixate on an object held 18 in. at eye level in front of nose.

1. Cover left eye for 3 s and note behavior of right eye. If right eye moves, note the direction.

2. Uncover left eye and note behavior of left eye. If left eye moves, note the direction.

3. Cover right eye for 3 s and note behavior of left eye. If left eye moves, note the direction.

4. Uncover right eye and note behavior of right eye. If right eye moves, note the direction.

Figure 2. Modified changing consistency board.